

EFFECT OF BROAD BEAN VARIETIES AND FABA BEAN UPON POPULATIONS DYNAMIC OF *BRUCHUS RUFIMANUS* (COLEOPTERA: CHRYSOMELIDAE: BRUCHINAE) IN KABYLIA REGION (ALGERIA)

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ABSTRACT

The present study aimed to examine the process and conditions of broad bean *Bruchid* *B. rufimanus* infestation in the field in Kabylia region (Algeria). *B. rufimanus* adults colonized progressively the cultures of Aguadulce variety and faba bean at the beginning of the flowering period, while it colonized Seville variety culture during the flowering period. This colonization seemed to depend upon climatic factors and host plant phenology. The presence of adults in plots spanned about 5 weeks for Aguadulce variety, 6 for faba bean and 4 weeks for Seville variety. At the end of the flowering period, the number of adults decreased whereas the number of mature pods increased for all plots. The egg-laying was spread over a period of approximately 8 and 7 weeks for Aguadulce and Seville varieties respectively and 6 for faba bean. Females seemed to deposit their eggs randomly on the available young pods and old pods of each host. Our results showed also that the varieties act significantly on the rate of infestation by *B. rufimanus* females on *V. faba* plots studied.

KEYWORDS: *Vicia Faba*, *Bruchus Rufimanus*, Egg-Laying, Varieties, Host Plant Colonization, Kabylia Region

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INTRODUCTION

Bean or faba bean (*Vicia faba* Linné) is a most cultivated Leguminosae seeds for human consumption in the Maghreb (Kharrat and al., 2002). In Algeria, they represent, in rural areas and at household with limited income, a large part of the food ration (Amamra, 2002). They are also used as green manure for poor soils in arid areas of Algeria (Chafi and Bensoltane, 2009). However, this culture is subject to insect belonging to the family of Chrysomelidae in the field and continues to develop as larvae in warehouses.

Bruchus rufimanus (Boheman, 1833) (Coleoptera, Bruchinae) is the major insect pest of bean and faba bean seeds. Adults colonize crops and give birth to a new generation in warehouses. Its life cycle depends on that of its host plant, which is split into two phases. The first is where the reproductive activity of adults is conditioned by the presence of its host plant *V. faba* during flowering and fruiting. The second is where adult weevils of the new generation which are in reproductive diapause, remain inside seeds or emerge to winter in natural sites. The later can be trees, lichens, soil crevices or warehouses (Yao et Yang, 1985 ; Huignard and al., 1990). They can also come from no "disinfected" seeds, which still host living weevils at planting (Dupont and Huignard, 1990).

Our study aimed to examine process of infestation of faba beans and broad beans by *B.rufimanus* adults and the conduct of the colonization of these cultures which are analyzed by comparing, in the field, plots of two varieties of broad beans and faba beans in Kabylia region of Algeria. Knowledge of these factors will allow

undertaking appropriate control against *B. rufimanus*.

MATERIALS AND METHODS

Host Plant

This study was conducted in two plots where two varieties of broad bean (*V. faba* L.var. major) namely Seville and Aguadulce and one plot of faba bean (*V. faba* L.var.minor) are grown, from February to May 2013. The plots, of approximately 100m² each, are located 10km east of Tizi-Ouzou city (Algeria North 36 ° 42 'North latitude and 4 ° 13' East longitude 36 ° 42 'NL) in the same station at an altitude of 100m. The soil is silty clay type. Seeds of each variety came from previous harvests in Kabylia region (Algeria) and are not "disinsected".

B. rufimanus

B. rufimanus adults present in the plots are captured in the morning before temperatures do not exceed 15°C, this threshold corresponds to the imaginal activity temperature of the insect. Adults are sought for at the flowers, leaves, leaf cones and other parts of the plant and by using a sweep net for individuals moving to the tops of the plants and in flight, by moving back and forth along a given transect on each studied plot. Observations are held once a week throughout colonization period (March-April 2013). Broad bean weevils are counted and "sexed" in the laboratory.

Oviposition

From the start of egg laying at harvest, ten cloves of raw inflorescences (Mature pods) and ten cloves formed from the last inflorescences (young pods) are selected randomly on ten stems of broad bean and faba bean browsing each plot. These pods are observed under a dissecting microscope to count eggs on the pericarp and then measured with a ruler (cm).

Statistical Analysis

Populations dynamic of *B. rufimanus* and pods infestation are analyzed using Student test and variance analysis (ANOVA) at the 5% threshold, with one (variety) or two (variety and sex) classification criteria. This is complemented by the Newman-Keuls test (p<0.05) (Dagnelie, 1975) using Stat-box software program (version 6.4).

RESULTS

Adult Number Captured During the Flowering Period

Aguadulce Variety Plot

The first weevils were captured on March 14 with 2 individuals; one male and one female (Figure 1a), a week after the start of flowering. This number increased gradually to reach a peak of 21 males and 16 females recorded on March 28, coinciding with the full flowering with 4.3 inflorescences (± 0.8) where flowers serve as their food substrate. To date, the photoperiod was about 10h20min with a daily average temperature of 13.80°C. The number of weevils captured was down more and more important; 9 individuals were captured on April 4; 4 individuals on April 11 and one individual was captured the 18th of the same month. From April 25, no weevil was observed or captured in this plot. A total of 61 adults is recognized, of which 33 are males (sex ratio = number of males / total number of insects caught = 0.54).

Seville Variety Plot

The arrival of *B. rufimanus* in this plot was similar to the other plots (Figure 1b), this appearance coincides with the maximum of inflorescence number of about 4.5 (± 1.2) and a photophase of 9hours and 58minutes, while the daily

average temperature was 16,80°C. During March 14, a total of 14 adults is recorded, 10 are males. The maximum number is noted on March 28 with a total of 31 weevils which 17 are males. In this plot, a total of 84 weevils is captured, of which 54 are males (sex ratio = 0.64). From April 18, a total lack of adults is observed.

Faba Bean Plot

The colonization of this plot was identical to that of Aguadulce with 2 males (Figure 1c) recorded at a 9h58mn photoperiod and a daily average temperature of 18.90°C. This temperature supports the activity of the pest. Such as Aguadulce variety, the maximum number is noted on March 28, with 25 weevils, including 14 males. The presence of flowers of *V. faba*, whose maximum recorded, was about 4.3 inflorescences (± 0.7) and the favorable climatic conditions (including temperatures, with a daily average of 13.80°C) favor the activity of weevils. From April 25, a total absence of adults is noted in the plot. A total of 47 weevils captured, 26 are males (sex ratio = 0.55).

Variance analysis revealed a highly significant effect of broad bean varieties and faba bean on the activity of *B. rufimanus* adults (Table 1).

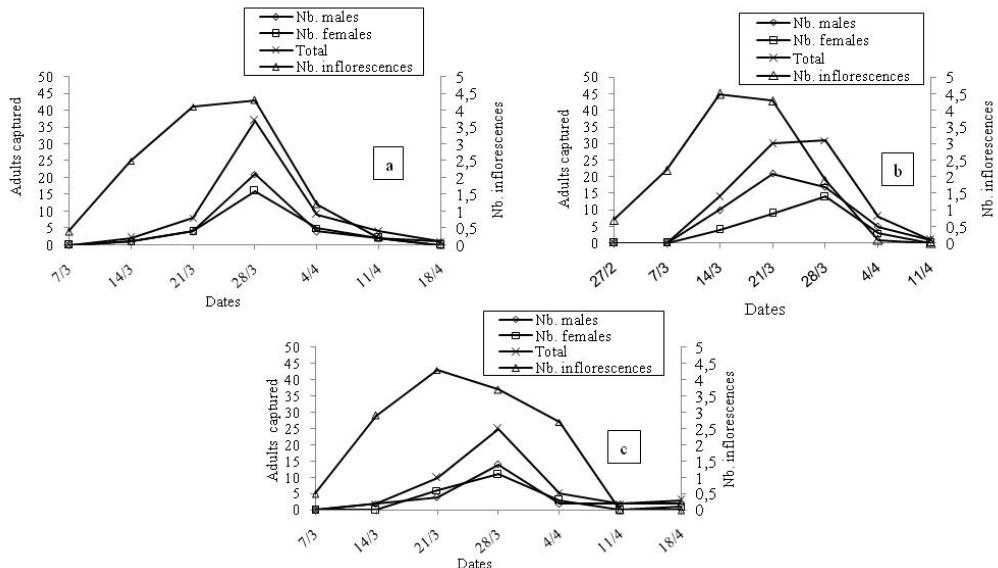


Figure 1: Number of *B. rufimanus* Adults Captured According to the Mean Number of Inflorescences on Aguadulce (a) and Seville (b) Varieties and Faba Bean (c)

Table 1: Effect of Two Varieties of Broad Beans and Faba Bean (Number Means) on the Activity of *B. rufimanus* Adults

		Average \pm SD	ANOVA	
			Test F	Prob.
Varieties	Seville	1,75 \pm 0,72 a	4,78	0,0057**
	Aguadulce	1,27 \pm 0,51 b		
	Faba bean	0,98 \pm 0,44 b		
Sex	Males	1,52 \pm 0,52 a	9,81	0,0031**
	Femelles	1,04 \pm 0,52 b		

Means with different letters in the column are significantly different using ANOVA ($\alpha=0.05$). (**): ($\alpha=0.01$).

Average Number of Eggs Lay

Aguadulce Variety Plot

Females began to lay their eggs on older pods and young pods with respectively 0.7 (± 1.3) eggs / pod

(with 3 cloves on 10 are infested) and 1.5 (± 1.8) eggs / pod (deposited on 50% of sampled pods). The average size of these pods is about 5.5cm (± 0.8) for aged pods and 10.2cm (± 3.3) for young pods (Figure 2). Eggs number increases gradually to attain a maximum of 2.7 (± 1.7) eggs / pod on the lower pods noted on April 11, where 10 of 10 pods are infested. The average number of eggs per pod decreases from 18 April. A slight increase is observed on May 16 with 1.4 egg / pod (± 2.5) and canceled on May 24 due to pods desiccation. On the upper pods, egg laying appeared on April 18 and regresses from that date until May 16, where a slight increase was recorded before it regresses again. From a total of 138 eggs laid in this plot, only 45 eggs are laid on young pods. However, Student test did not reveal significant differences ($t_{obs}=1.44 \alpha = 0.05 P = 0.08$).

Seville Variety Plot

Egg laying began on March 28 for older pods and 18 April for young pods with respectively 2.1 (± 2.5) and 2. 2 (± 2.6) eggs per pod, when their average sizes are of 5,6cm (± 0.9) and 10,9cm (± 3.1) respectively; eggs are laid upon 70% of pods (figure 2). The average number of eggs peaked on April 4 for pods of the lower stratum with 2.4 (± 1.9) eggs per pod deposited on 90% of sampled pods. For upper stratum, the peak is observed at the beginning of laying noted on 18 April. The end of oviposition was observed on 9 and 24 May for the low and high stratum respectively. In this plot, egg laying extends over a month and 4 days for the lower stratum, where a total of 77 eggs was recorded and 4 weeks for the upper stratum with 40 eggs in total. Student test did not reveal any significant difference between the two strata ($t_{obs.} = 1.02 \alpha= 0.05 P=0.16$).

Faba Bean Plot

Older pods began receiving eggs as they emerge noted on March 28 when their sizes reached 3.7cm (± 3.2) (Figure 2); an average density of 0.1 (± 0.3) eggs/pod is noted with one pod of 10 infested. The maximum of egg laying is observed on April 11 with 1.1 (± 1.0) eggs/pod recorded on 60% of sampled pods when measuring 6.3cm (± 1.3) on average. This density decreases slightly during the third week of April to cancel on May 25. The pods from last inflorescences began receiving eggs, as they appear on April 18, with an average density of 0.9 (± 0.8) eggs/pod when measuring 6.3cm (± 1.2) in average and where 6 of 10 pods are infested (Figure 2). The maximum of eggs laid by *B. rufimanus* females on these pods is 1.1 (± 1.0) eggs/pod, when the average size of them reached 5.7cm (± 2.3) (6 upon 10 pods are infested) and 6.2cm (± 2.2) (7 of 10 pods are infested) respectively noted on May 2 and 9. The average egg density decreases slightly to cancel on May 24. In this plot, oviposition lasted a month and about 15 days, where a total of 94 eggs are recorded of which 50 are laid on the pods of the lower stratum. Student test shows that the infestation varies insignificantly between the two strata ($t_{obs}=0.29 \alpha=0.05 P= 0.39$).

Variance analysis revealed that the rate of infestation by *B. rufimanus* females varies significantly between studied varieties (Table 2).

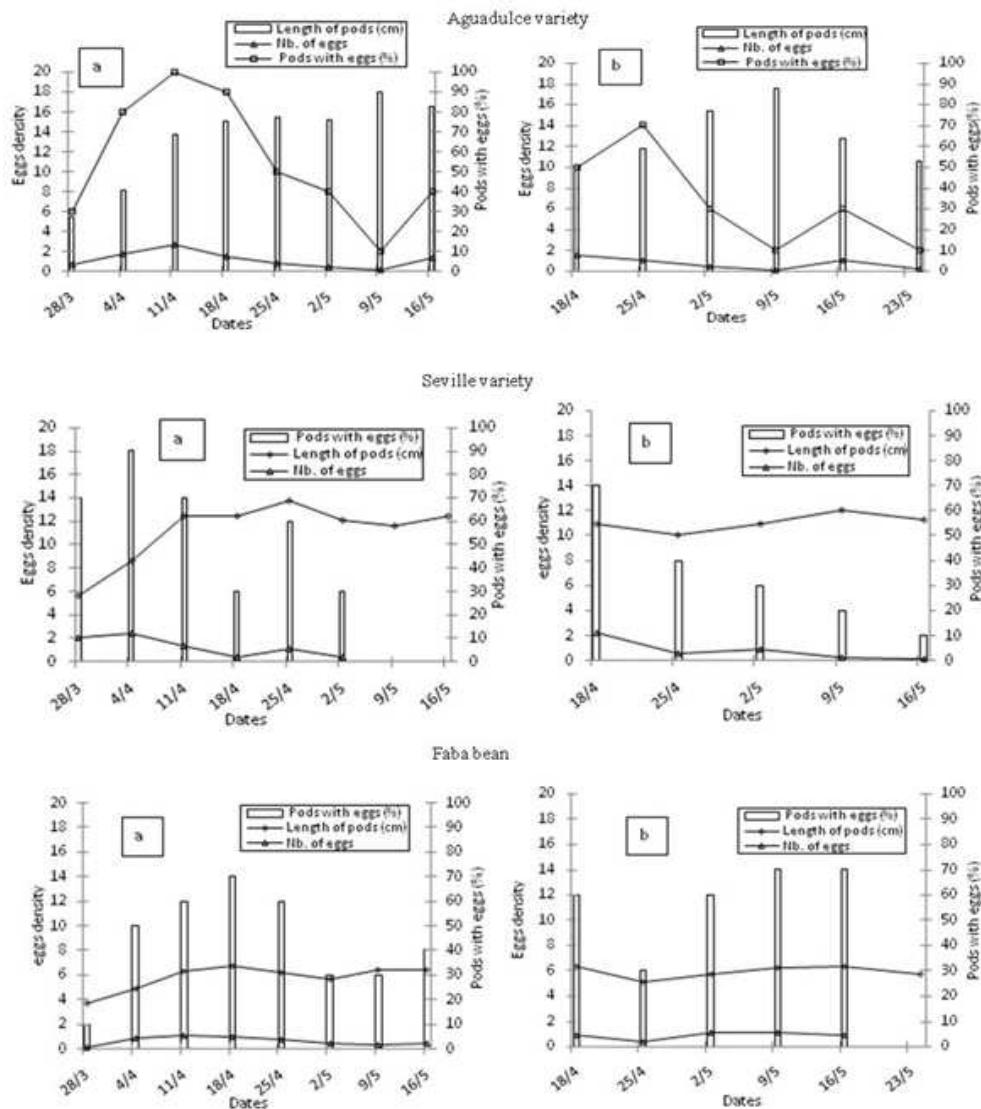


Figure 2: Temporal Evolution of Mean Density Eggs Laid by *B. rufimanus* Females and Percentages of Pods with Eggs for Old Pods (a) (Sampled on Mars 28) and for Young Pods (b) (Sampled on April 18) on Aguadulce and Seville Varieties and Faba Bean

Table 2: Estimated Infestation (Egg Number Means) of Pods on the Different Varieties of Broad Bean and Faba Beans

Varieties		Average \pm SD	ANOVA	
			TestF	Prob.
Aguadulce		1,38 \pm 0,78 a		
Seville		1,17 \pm 0,90 ab	3,262	
Faba bean		0,91 \pm 0,42 b		0,0363*

Means with different letters in the same column are significantly different using ANOVA at 5%. (*): ($\alpha=0.05$).

DISCUSSIONS AND CONCLUSIONS

The present study on the choice of the broad bean weevil for varieties of its host plant of *V. faba*, showed that before flowering, no adult of *B. rufimanus* is observed in the plots. The first weevil arrival coincides with the flowering period of the host plant; Aguadulce and faba bean plots are colonized at the beginning of flowering while Seville plot is

colonized in full bloom. These results are consistent with those found by Dupont and Huignard (1990) on faba bean fields. The same phenomenon is observed in other species of the genus *Bruchus*. In fact, Huignard and al. (2011) reported that pea field colonization by *Bruchus pisorum* adults begins at the flowering stage. Luca (1966) reported that, in Algeria, adults of *Bruchus latus* colonize lens fields during the flowering phase occurring on May. On the other side, Boughdad (1994) and Medjdoub-Bensaad and al. (2007) found that adults are also observed on the host plant in the vegetation stage. These fields are colonized prematurely by *B. rufimanus* adults that can come from over wintering sites like seeds used for sowing hosting living weevils at planting (Franssen, 1956; Robert and al., 1975 ; Medjdoub-Bensaad, 2007) as in our case; or in wintering natural sites such eucalyptus bark (Chakir, 1998) present in the study site. Dupont (1990) indicated that temperature seems to be one of the main factors that trigger the departure of *B. rufimanus* adults towards the bean fields from diapause sites; for Tran (1992), it is the decrease of the photoperiod, which causes the induction of diapause while its increase causes the rupture of the latter. Hoffmann et al. (1962) reported that high relative humidity and heavy rain forced the adults to take shelter in leaf cones and their activity is important when temperatures are near to 17°C. For Franssen (1956), 15°C is the optimum temperature for the imaginal activity of *B. rufimanus*. After bean flowering, the numbers of adults in cultures decreased. This decrease was due to the scarcity of flowers, the maturation of pods and probably to the end of the reproductive activity of the pest. Dupont (1990) reported that *B. rufimanus* adults move to other weed flowers such as *Prunus spinosa* (Rosaceae), *Vicia sativum* (legume, papilionaceous) on which they continue their feeding activity. Similar findings are reported by Bashar (1988) who noted that *Bruchus affinis* consumes *Lathyrus pratensis* pollen before its host plant *Lathyrus sylvestris* is in bloom. This pollen supply constitutes, in the absence of bean flowers, energy intake to maintain the reproductive activity of the bean weevils allowing them to colonize other later plots.

In our case, the colonization periods of studied plots by *B. rufimanus* adults are 5 weeks for Seville and faba bean and about 6 weeks for Aguadulce. According to Medjdoub-Bensaad and al. (2007), the appearance of the flowers of *V. faba* allows the lifting of diapause and that of the first pods allows then the induction of egg laying, as is also the case in *B. affinis* (Fabres and al., 1986). The result is thus a perfect synchronization between the activity period of egg laying and pod formation. In fact, monitoring oviposition period of *B. rufimanus* females in the studied plots shows that eggs are deposited on the pods as they become available. Egg laying by *B. rufimanus* females began on March 28 for the three investigated plots. This laying activity is spread over a period of about 8 weeks for Seville variety and faba bean and 9 weeks for Aguadulce variety. Indeed, Boughdad (1994) reported that at the beginning of their laying period, when the temperature conditions are favorable, females release eggs on green pods along 2.5cm which still wrapped in the faded petals. Fabres et al. (1986) observed the same behaviour in *B. affinis* on *Lathyrus sylvestris*. Therefore, Hoffmann and Labeyrie (1962) reported that the weevil oviposition starts when bean pods are 4 to 5cm long. Medjdoub-Bensaad (2007) study performed upon *B. rufimanus* in the same area in Kabylia (Algeria) showed that egg laying period varies from year to year depending on the region, it spreads over a period of 1 month to 2 months and a half covering widely the period of pods growth. Under Moroccan weather, Boughdad (1994) noted an oviposition period of 49 days while Boughdad and Lauge (1997) noted an oviposition period of 32 days. This result is similar to our observations for Seville variety. In the Netherlands, Franssen (1955) indicated shorter duration of *B. rufimanus* egg laying period of about 17 days in 1951 and 4 days in 1954.

Although, eggs number is higher in older pods, our results showed that *B. rufimanus* females do not exhibit any significant difference in egg laying between older and young pods for both varieties of broad bean and faba bean. In contrast, results of Smith (1990) and Medjdoub-Bensaad and al. (2007) indicated that females prefer to lay on older pods than on young pods and according to Hoffmann et al. (1962), early or older pods are more exposed and receive therefore

more eggs than late pods (young). In fact, infestation depends on levels of insect populations, pod exposure time or a relatively high pod size enabling them to carry more eggs.

If females are sexually mature at the occurrence of the first pods, the latter receive a very high concentration of eggs, as observed by Speyer (1949 in Balachowsky, 1962) and (Smith, 1990). The latter author found that 28% of pods at the base of the plants (the first formed) received eggs while the rate is about 7% for the highest level of pods (the latest formed). Furthermore, the vegetative state of the plant and weather can disrupt laying activity. Denlinger and al. (2005) reported that the diurnal temperature differences can modulate the activity and the laying period of the insect. When the relative humidity is high, egg emission by beetle females is difficult (Boughdad 1994). At the end of oviposition period, pods receive fewer and fewer eggs because of the reduction of laying activity and mainly with the change in pods texture. Chakir (1998) reported that the increase in pods number lead to the dispersion of egg laying inducing a low density of egg laying. In the majority of phytophagous insect species, the choice of oviposition support by females is a crucial step for the survival of their offspring (Singer, 1991). According to Boughdad (1994), the destiny of future larvae depends upon, the success of their installation in the seeds depending on the location of the egg in the pod.

Finally, we conclude that, the study of the choice of *B. rufimanus* adults for the different varieties of its host plant *V. faba*: Aguadulce, Seville and faba bean in the field shows that *B. rufimanus* is a monovoltine species with a colonizing ability. Fields colonization is done by adults, either by accompanying the seed during sowing, either from overwintering sites. The host plant as a food source plays a key role in *B. rufimanus* population dynamics and leads to a finer adjustment between egg laying and pod formation. *B. rufimanus* females show no preference in laying eggs on older pods and young pods for broad bean and faba beans. However, infestation is highest on the variety Aguadulce, suggesting that the pest expresses a preference for this variety. The control of this pest, considering the profitability of the crop, should start with less expensive farming techniques such as the use of healthy seed, removal of weeds, which are an additional food for the insect. Chemical control in the field, must aim adults to prevent egg laying. The destruction of *B. rufimanus* adults before their escape from stocks reduces the source of infestation. The possibilities of adult moving are that the control must be undertaken throughout the region, by raising awareness of farmers. The extraction of substances from plants with insecticidal activity and their use may constitute a biological solution that is both effective and economical.

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